iterative process which may be enhanced (i.e. fewer iterations required) by the skill and experience of the designer.

A further empirical design technique involves designing a first pass end effector in the manner set forth above. A physical model of the first pass end effector is then built and tested by driving the input of the transmission waveguide at a suitable generator frequency. The frequency at which the end effector is driven may be referred to as the drive frequency. With the first pass end effector driven at the drive frequency, a suitable measurement of the torque generated at the balance node may be selected, for example, the balance ratio can be measured directly from the transmission waveguide. The end effector may then be balanced (i.e. the balance ratio reduced to less than 1;10) by physically adding or subtracting mass in the balance region. This is, of course, an iterative process which may be enhanced (i.e. fewer iterations required) by the skill and experience of the designer. No matter the design method chosen, whether empirical or analytical, if it is an iterative process, the rougher the first approximation used, the more iterations will be necessary to arrive at balanced blade design.

As described herein, balance node **22** was selected as the proximal origin of balance region **26** in order to provide clarity and to set forth a physically definable point of reference which may be located on any transmission waveguide, using either mathematical computation or physical measurements. As it happens, using node **22** as the proximal origin of balance region **26** is also beneficial in that it is believed to make the mathematics set forth herein cleaner and more understandable. However, it should be recognized that using the present invention, the undesirable torque generated in the waveguide will be substantially canceled by the balance torque generated in the wave guide from a point just proximal to the proximal most balance asymmetry. For example, in the embodiment of the invention illustrated in FIG. **2**, the torque will converge toward zero in the portion of the waveguide proximal to first predetermined point **42**.

While the embodiments illustrated and described herein have beneficial asymmetries in only one direction, the present technique could be used to balance blades having asymmetries in any two or more directions. It will be further be apparent that, in a surgical end effector designed according to the present invention, the center of mass of the end effector may not be positioned on the central axis of the waveguide. A blade according to the present invention may also be designed to include a single or multiple angle of curvature and to include blunt, square or sharp blade edges. A balanced ultrasonic blade designed according to the present invention may be used to perform many open and endoscopic surgical procedures, including; internal mammary artery (IMA) takedown procedures; removal or dissection of the radial artery; breast reduction and reconstruction; and hemorrhoid removal. Ultrasonic blades, according to the present invention, have multiple functions and may include multiple features to facilitate those functions, for example, flats or blunt regions for configuration, sharp or dull edges and serrated blade edges.

The trapezoidal shape of a blade according to the present invention is particularly advantageous for a number of reasons. In particular, in a trapezoidal blade according to the present invention, the central ridge adds stiffness, reducing stress in the blade. Further, using a trapezoidal shaped blade, it is possible to vary the blade edge sharpness and thickness to accommodate a number of clinical needs. Further, by including a small ridge surface at the center of the concave side of the blade as described herein, the concave side may be used to coagulate tissue which is cradled in the blade, thus, holding the tissue as it is coagulated and preventing it from slipping off the blade. It will be apparent to those skilled in the art that the present invention is directed not only to blades having a trapezoidal shape but also to blades having a shape which is substantially trapezoidal. For example, one or more of surfaces **32**, **33** or **37** may be slightly or more deeply curved without departing from the scope of the original invention. In another embodiment of the present invention, surfaces **33** and **37** may be blended to form a more rounded concave surface **30**.

While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

What is claimed is;

1. A curved ultrasonic surgical blade wherein said curved ultrasonic surgical blade comprises;

a concave top surface including a central ridge;

a convex bottom surface wherein said convex bottom surface has a width greater than twice the width of said central ridge; and

first and second side walls connecting said convex bottom surface to said central ridge, said first and second side walls forming a portion of said concave top surface,

wherein said ultrasonic surgical blade has a substantially trapezoidal cross-section.

2. A curved ultrasonic surgical blade according to claim **1** wherein said convex bottom surface is substantially parallel to an upper surface of said central ridge.

3. A curved ultrasonic surgical blade according to claim **1** wherein said first side wall intersects said convex bottom surface to form a sharp blade edge.

4. A curved ultrasonic surgical blade according to claim **1** wherein said first side wall intersects said convex bottom surface to form a blunt blade edge.

5. A curved ultrasonic surgical blade according to claim **4** wherein said blunt blade edge is square.

6. A curved ultrasonic surgical blade according to claim **1** wherein said convex bottom surface has a width greater than three times the width of said central ridge.

7. A curved ultrasonic surgical blade according to claim **6** wherein said first and said second side walls intersect to form a sharp blade edge.

8. A curved ultrasonic surgical blade according to claim **6** wherein said first and said second side walls intersect to form a blunt blade edge.

9. A curved ultrasonic surgical blade according to claim **8** wherein said blunt blade edge is square.

10. A balanced ultrasonic surgical instrument including a curved ultrasonic surgical blade, wherein said ultrasonic surgical instrument comprises;

an ultrasonic transmission rod having a proximal end and a distal end;

a balance region including first and second balance asymmetries wherein said balance region extends from a node point at said distal end of said ultrasonic transmission rod to a proximal end of said curved ultrasonic surgical blade, wherein said curved ultrasonic surgical blade comprises;

a distal end;

a proximal end connected to said balance region;

a concave top surface including a central ridge;

a convex bottom surface wherein said convex bottom surface has a width greater than twice the width of said central ridge; and

first and second side walls connecting said convex bottom surface to said central ridge, wherein said first and second side walls form a portion of said concave top surface such that said curved ultrasonic surgical blade has a substantially trapezoidal cross-section.

11. A balanced ultrasonic surgical instrument according to claim **10**, wherein said first and second balance asymmetries are positioned to counter torque created in said proximal end of said blade by said curved ultrasonic surgical blade.

12. A balanced ultrasonic surgical instrument according to claim **11**, wherein said first and second balance asymmetries are positioned such that transverse vibrations in said ultrasonic transmission rod are substantially equal to zero.

13. A balanced ultrasonic surgical instrument according to claim **11** wherein the balance ratio of the transmission waveguide is less than 1:10.

14. A balanced ultrasonic surgical instrument according to claim **13** wherein the balance ratio of the transmission waveguide is less than 1:200.

15. A balanced ultrasonic surgical instrument according to claim **10** wherein said first and said second side walls intersect to form a sharp blade edge.

16. A balanced ultrasonic surgical instrument according to claim **15** wherein said first and said second side walls intersect to form a blunt blade edge.

17. A balanced ultrasonic surgical instrument according to claim **16** wherein said blunt blade edge is square.

18. A balanced ultrasonic surgical instrument according to claim **10** wherein said curved blade and said balance region are bisected by a plane of symmetry, said curved blade being substantially symmetrical on either side of said plane of symmetry, said first balance asymmetry comprising a flat surface in said balance region wherein said first flat surface is substantially perpendicular to said plane of symmetry and said second balance asymmetry comprises a second flat surface in said balance region opposite said first flat surface wherein said second flat surface is substantially perpendicular to said second plane of symmetry.

19. A balanced ultrasonic surgical instrument according to claim **18** wherein said first balance asymmetry is shorter than said second balance asymmetry.

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42	2	("5318570").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2002/12/14 16:12